

Remarks

Information Disclosure Statement

The Examiner asserts that a copy of the non-patent literature of Shigetoshi Uot, et. al, was not submitted with the information disclosure statement filed November 12, 2003. The on-line contents of the Image File Wrapper shows that the reference was submitted; however, it is attached to the end of another reference. For the Examiner's convenience, an additional copy of the document is submitted herewith.

Claim Rejections 35 USC § 112

The Examiner's recitation of which claims were rejected under 35 USC § 112, second paragraph, appears to be in error. The following comments are directed to claims 9, 10, 15, 16 and 19 in an effort to provide a thorough response.

Claims 9 and 10 have been amended to recite "an application temperature" to provide the necessary antecedent basis. Support for the amendments to claims 9 and 10 is found in the specification at page 5, lines 6-8; page 6, lines 18-22; page 7, lines 18-20; and page 8, lines 3-5.

Claim 15 has been amended to clarify that certain verbiage originally included within parentheses refers to mass percent of the respective component in the claimed batch; the phrase "fine-grained silica" has been deleted as superfluous material; and the phrase "in particular, mineral oil" has been deleted as being merely explanatory.

Claim 16 has been amended to recite "wherein Al_2O_3 is provided as reactive alumina" to remove the language deemed to be indefinite.

Claim 19 has been amended to recite the method/process steps of "throwing a sack, including

the batch in dry form on a damaged site so that the sack splits and the batch gets in contact with the refractory lining.” Support for the amendment to claim 19 is found in the specification at page 3, lines 16-22; page 4, lines 22-23-page 5, lines 1-2; at page 8, lines 4-11.

It is requested that the rejections of the claims under 35 U.S.C. § 112, second paragraph, be withdrawn.

Claim Rejections : 35 USC § 101

Claim 19 was rejected under 35 U.S.C. § 101 as claiming a “use” without setting forth any steps involved in the process. Claim 19 has been amended as explained above to provide the required recitation of method/process steps. It is requested that this rejection of claim 19 be withdrawn.

Claim Rejections: 35 U.S.C. § 102 and § 103

Claims 1-19 were rejected under 35 U.S.C. § 102(b) as being anticipated by Naito et al. (US Patent No. 4,334,029).

Claims 3 and 17 were rejected under 35 U.S.C. 103(a) as being unpatentable over Naito et al. (US 4,334,029).

35 U.S.C. § 102 Rejections: The Applicable Legal Standards

Anticipation pursuant to 35 U.S.C. § 102 requires that a single prior art reference contain all the elements of the claimed invention arranged in the manner recited in the claim. *Connell v. Sears, Roebuck & Co.*, 722 F.2d 1542, 220 U.S.P.Q. 193, 198 (Fed. Cir. 1983).

Anticipation under 35 U.S.C. § 102 requires in a single prior art disclosure, each and every element of the claimed invention arranged in a manner such that the reference would literally infringe the claims at issue if made later in time. *Lewmar Marine, Inc. v. Barient, Inc.*, 822 F.2d 744, 747, 3 U.S.P.Q. 2d 1766, 1768 (Fed. Cir. 1987).

Anticipation is established only when a single prior art reference discloses, expressly or under principles of inherency, each and every element of a claimed invention. *RCA Corp. v. Applied Digital Data Sys., Inc.*, 730 F.2d 1440, 1444, 221 U.S.P.Q. 385, 388 (Fed. Cir. 1984).

35 U.S.C. § 103 Rejections: The Applicable Legal Standards

The Office has the responsibility to present a *prima facie* case of obviousness under 35 U.S.C. § 103. An Applicant is entitled to a patent if the Office fails to establish a *prima facie* case of obviousness. *In re Oetiker*, 24 U.S.P.Q. 2d 1443 (Fed. Cir. 1992). In determining obviousness under 35 U.S.C. § 103, the invention must be considered “as a whole.”

Any modification of the cited reference in order to arrive at Applicant’s invention must be motivated by the cited art. *In re Deminski*, 230 U.S.P.Q. 313 (Fed. Cir. 1986). Applicant’s own disclosure may not serve as a template to piece together the teachings of the prior art to render the claimed invention obvious. *In re Fitch*, 23 U.S.P.Q. 2d 1780 (Fed. Cir. 1992). There must be a reason or suggestion in the prior art for selecting the claimed procedure, other than knowledge learned from Applicant’s disclosure. *In re Dow Chemical*, 5 U.S.P.Q. 2d 1529 (Fed. Cir. 1988). Further, the motivation for modifying a reference cannot be found if the reference actually “teaches away” from the claimed invention. *In re Gurley*, 31 U.S.P.Q. 2d 130 (Fed. Cir. 1994).

Generally Applicable Comments:

It is respectfully submitted that the rejections made under 35 U.S.C. § § 102 and 103 set forth in the Office Action do not meet these burdens.

The Applicants' invention relates to a non-basic refractory batch for making repairs of hot refractory surfaces (Claim 1; page 3, lines 7-8). Applicants' invention is based on the inventive concept of using a specific combination of water-free binders (Claim 1, criteria 1.21 and 1.22).

These specific binder-combinations contain no crystalline water, but melt quickly when exposed to the higher temperatures at which the repairs are made.

In the cited reference, Naito describes the disadvantages of siliceous, carbonaceous and phosphatic binders at column 2. Naito particularly points out the disadvantages of low mechanical strength (Col. 2, line 7), the insufficient structure (Col. 2, line 34) and the poor pot life (Col. 2, line 45) of the corresponding refractory products.

To overcome the cited disadvantages, Naito teaches an unfired refractory composition, comprising refractory aggregate and a combination of:

- a) a water soluble or water dispersible siliceous alkali metal borosilicate binder with a specific M_2O/SiO_2 ratio -AND-
- b) a carbonizable organic binder, -AND-
- c) a phosphate type hardening agent.

According to Naito, all three components must be present (Col. 3, lines 48-51: "Furthermore, if any one of the three components of the binder is not incorporated, the mechanical strength in the intermediate temperature region can hardly be increased to a satisfactory level.") In fact, the reference chart provided by the Examiner illustrating the mass percent of each component in the reference compositions clearly shows that the compositions include a siliceous binder, a C-forming

component, and a phosphate containing component.

According to the teachings of the reference, water is added to the batch (Col. 21, lines 5-7) to prepare a green composition which is then molded. The purpose and use of the Naito composition is different from Applicants' invention.

Claim 1:

In particular, claim 1, as amended, addresses a non-basic refractory batch for making repairs on hot refractory surface. The claimed batch contains the non-basic refractory material and a selected combination of additional components. The selected combination may be either a combination of at least one phosphatic and at least one silicatic component -OR- a combination of at least one C-containing component and at least one silicatic component. This claim limitation is not anticipated by Naito. In fact, Naito expressly *teaches away* from the either/or scenario.

There is no disclosure in Naito of binder combinations having only 2 components according to criteria 1.2.1 and 1.2.2 of Applicants' claim 1. Additionally, the subject matter of original claim 4 has been incorporated into claim 1, as amended. Thus, the specific claimed binder components are selected from those which form a molten phase at temperatures > 500° C. The applied reference does not teach or suggest a refractory composition whose phosphatic and/or silicatic component forms a molten phase at temperature > 500° C.

Claims 2-19:

Each of the claims 2-19 ultimately depend from claim 1. As such, the comments directed to claim 1 apply equally well to claims 2-19 and are incorporated herein by reference. Additionally, claim 7 is directed to a batch wherein the silicatic component is present in a grain-size fraction <

0.3 mm. The cited reference does not provide any teaching as to the grain-size fraction of the silicatic component.

Claims 9 and 10 recite that the components in the batch are proportioned so as to provide at least 15 M-%, and at least 20 M-%, respectively, of a molten phase at an application temperature. Applicants' specification teaches use of the claimed composition on hot refractory surfaces. The cited reference provides no teaching directed to molten phases at an application temperature. In the reference, the composition is formed in a "green state" and then molded for use as a refractory product.

As to claims 3 and 17, in addition to the comments presented above, the claimed ranges for the non-basic refractory material (claim 3) and the total quantity of phosphatic and silicatic components (claim 17) fall outside the ranges provided in the cited reference. The Examiner uses the Abstract to support the rejection. However, the abstract clearly lists all three components conjunctively, a concept which teaches away from the instant claims.

One having skill in the art is therefore not motivated by the teachings of the cited reference to modify Naito to arrive at the claimed invention. Thus, claims 1-19, and particularly claims 3 and 17 are not anticipated by, nor obvious in view of, the cited reference.

Additional Comments:

The Applicants have not necessarily presented all of the reasons as to why Naito does not disclose or teach the claimed invention. Nevertheless, Applicants' remarks herein have shown that when the invention is taken as a whole, the cited reference does not teach or suggest the claimed invention, particularly with respect to the use of the term -OR- in claim 1. Additionally, one of ordinary skill in the pertinent art would not have been motivated by the teaching of the references

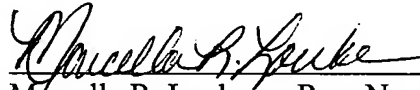
to have made the modifications proposed by the Examiner, especially since the reference teaches away. The Office has therefore failed to provide a *prima facie* case of obviousness within the meaning of 35 U.S.C. § 103(a). Thus, it is respectfully submitted that the rejections should be withdrawn.

Conclusion

Each of Applicants' pending claims specifically recite features and relationships that are neither disclosed nor suggested in any of the applied prior art. Furthermore, the applied prior art is devoid of any such teaching, suggestion, or motivation for modifying features of the applied art so as to produce Applicants' invention. Allowance of all of Applicants' pending claims is therefore respectfully requested.

The undersigned will be happy to discuss any aspect of the Application by telephone at the Office's convenience.

Respectfully submitted,



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Report:

Flowability and Hardening Time of Resin-Bonded Hot Repair Mixes

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1. Introduction

Hot repair mixes are indispensable for repairing damage, and prolonging the lining life of furnaces, such as BOF's. Hot repair methods, such as gunning, hot casting, and flame gunning are commonly used, in conjunction with slag coating methods. Hot casting repairs have especially been widely used to repair the BOF bottom and charging side impact area because equipment preparation is not necessary, and the placement of hot casting mixes through a scrap chute is a very simple method of repairing the lining. In this paper, resin-bonded hot repair mixes, which harden quickly and produce less smoke, are discussed.

2. Objectives of this Study

Repair mixes require both good hot flowability and short hardening time, but these properties are contrary to each other. In this study, the affects of different solvents and the molecular weight of novolac-type resin were studied, in an effort to achieve the desired characteristics. The study was also intended to design the quality of repair materials to meet the user's needs.

3. Comparison of Properties of Hot Repair Mixes

The following properties are generally required in hot casting repair mixes:

- (1) Hot flowability should be good ✓
- (2) Curing time should be short ✓

(3) The durability of the repair material should be excellent

Table 1 shows a comparison of properties of various hot repair mixes. Hot casting repair mixes can be divided into roughly two categories, i.e. (a) aqueous hot casting mixes and (b) non-aqueous mixes. The aqueous hot casting type mixes include a slurry mix which is prepared by nozzle mixing methods, like gunning on site⁽¹⁾, and a dry mix which includes a binder with structural water, that flows by release of the structural water in the hot condition⁽²⁾. The non-aqueous hot casting type mixes include a dry mix with pitch and phenol resin powder⁽³⁻⁶⁾, and a slurry mix with liquid phenol resin⁽⁷⁾.

Aqueous hot casting mixes have a shorter hardening time, but the durability is worse than the non-aqueous mixes, in which the binders are carbonized and form a carbon-bonded structure which has high hot strength. The carbonaceous binders used in non-aqueous hot casting mixes are pitch and novolac resin. When heated, pitch requires a longer time to decompose and polymerize than resin. Furthermore, pitch produces a lot of smoke in the process. On the contrary, resin is suitable to reduce hardening time and produce less smoke.

Resin-bonded hot casting repair mixes generally satisfy the requirements, but in service they do not flow well or have suitable hardening time. For example, when the temperature of the brick surface in a BOF is higher than usual, resin-bonded mixes don't flow into the repair site because the mix hardens too early if the BOF is tilted soon after the mix is put in place. Another example is when the

Table 1 Comparison of characteristics of hot repair mixes

Types of medium	Hot repair mixes			
	Water		Non-water	
		<i>solocarge</i>		
Appearance of products	Powder	Powder with structural water	pitch Powder	Resin Slurry
Preparation	Mixing by gunning machine	Nothing	Nothing	Nothing
Curing time (min) [500kg] at 1000°C ~1200°C	<10	<10	30	15
Durability	Not so good	Not so good	Good	Good
Bond	Phosphate	Phosphate Silicate	Carbon	Carbon

repaired mass is thick. Even if the surface of the repair mix looks stiff, the interior where it has not yet become stiff will flow when the BOF is tilted.

4. Experiment 1

4.1. Solvents and Resins Used

Four types of solvent were prepared, namely A, B, C, and D, which had different boiling points ranging from 171°C to 278°C (see Table 2). Solid novolac resins were obtained from companies X and Y. They had different molecular weights ranging from 400 to 1350.

4.2. Preparation of Liquid Resins

Liquid novolac resins were prepared by (a) changing the type of solvent and (b) using resins of different molecular weight. As for (a), solid novolac resin whose molecular weight was 650 was dissolved into the four different solvents mentioned above. As for (b), solid novolac resins with the different molecular weights were dissolved in solvent C. Generally the weight ratio of solid resin to the solvent in the liquid resin depends on the type of solvent and molecular weight⁽⁶⁾.

The viscosity of each liquid resin was adjusted in the range from 2 to 3 Pa · s at 25°C, by changing the weight ratio of the liquid. This gave a mix of reasonable viscosity.

If the viscosity was lower, there was a problem of segregation of coarse aggregate during long term storage or while being transported. If the viscosity of the mix was higher, it would not have good hot flowability.

4.3. Mixing

Magnesia aggregate of less than 4 mm was mixed in liquid novolac phenolic resins, as shown in Table 3. A powder mix with pitch was prepared for comparative study.

4.4. Measurement Methods

4.4.1. Hot Flowability

A 200 g sample wrapped in plastic was placed on a magnesia plate (114×114×15 mm) in an electric furnace that was held at selected temperatures (1000°C, 1200°C, 1400°C). After completion of the firing, the sample was removed from the furnace, and the change in dimension of the mass was measured (see Fig. 1). For the powder mix with pitch, a 150 g sample was used because of its low aerated bulk density.

4.4.2. Hardening Time

A 250 g sample was placed in a steel can and inserted in an electric furnace at 350°C, along with several other cans containing samples. One can was removed at each speci-

Table 2 Characteristics of solvents evaluated

Solvent	A	B	C	D
Boiling Point (°C)	171	198	244	278
Viscosity $\times 10^{-3}$ (Pa · s) at 25°C	5	17	30	40

Table 3 General composition of samples evaluated

Factors	Solvent				Molecular weight	Pitch bonded
MgO Clinker	○	○	○	○	○	○
Metal Powder	○	○	○	○	○	○
Pitch						○
Resin (Powder)						○
Resin (Liquid)	○	○	○	○	○	
Molecular weight	650	650	650	650	400~1350	
Solvent	A	B	C	D	C	

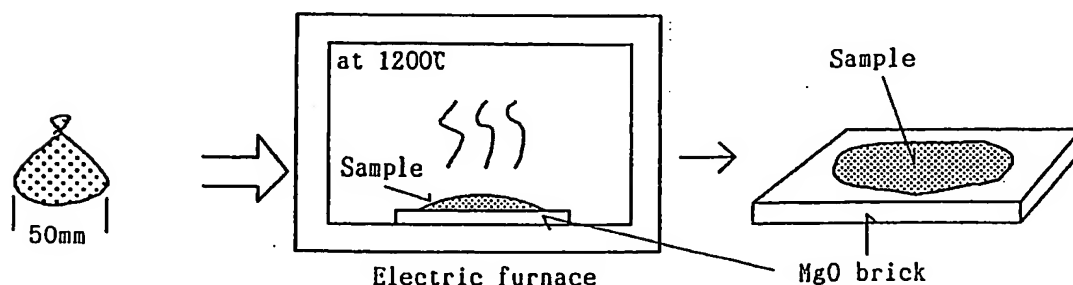


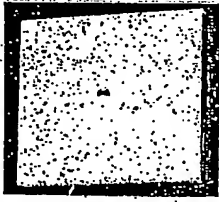
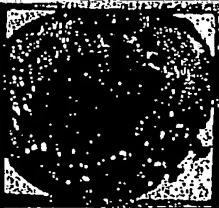
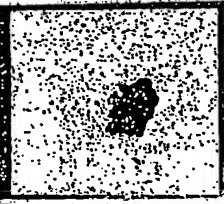

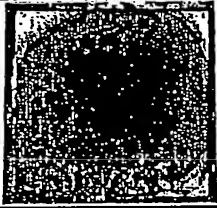
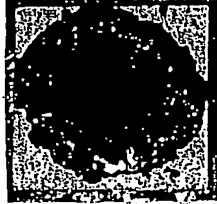
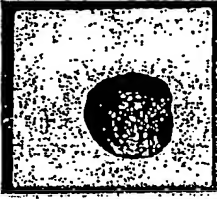
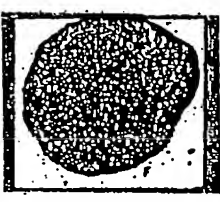
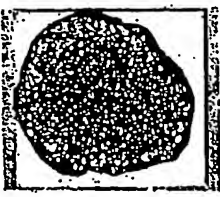



Fig. 1 Test method for hot flowability

Curing time (min) Mixes	20	25	30	40	45	60	80
Case of solvent B							
Case of solvent C							
Case of solvent D							
Ordinary pitch bonded mix							

The appearances of specimens after hardening time test at 350°C

Fig. 5 Appearance of samples after the hardening time test at 350°C

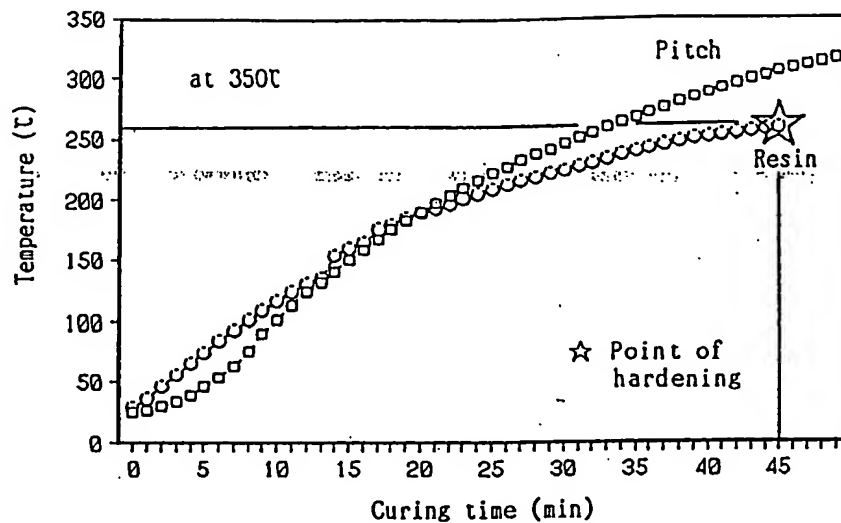


Fig. 11. Relationship between curing time and interior temperature of mixes exposed at 350°C

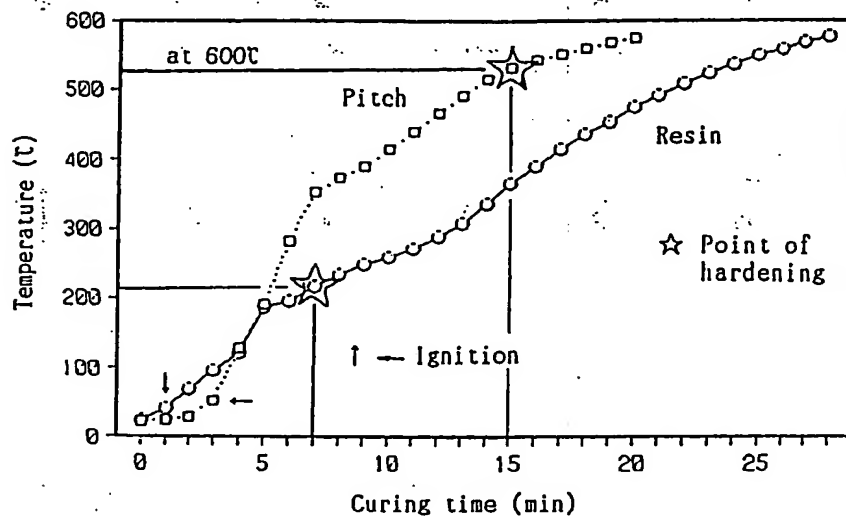


Fig. 12. Relationship between curing time and interior temperature of mixes exposed at 600°C

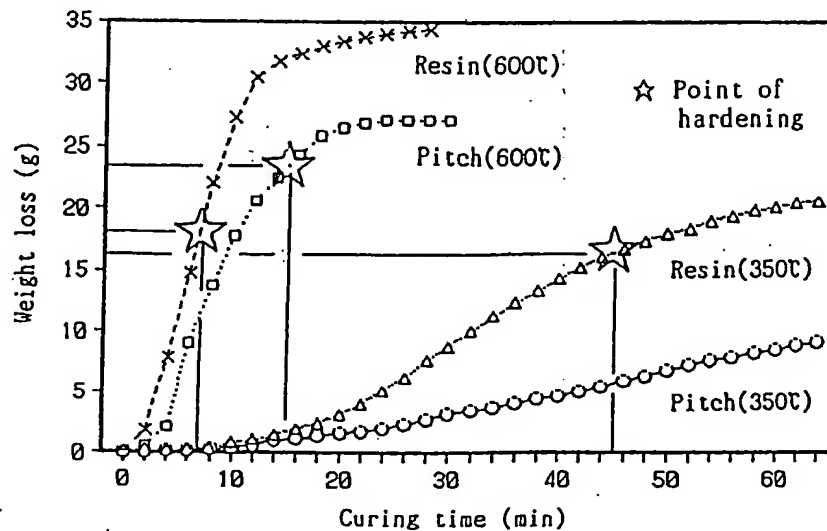


Fig. 13. Relationship between curing time and weight loss of mixes

Table 4 Time required (curing time) for temperature to reach 250°C at the center of repair mixes for various furnace temperatures

Curing time (min)		Furnace temperature (°C)		
		800	1000	1200
Thickness of repaired body (mm)	100	11	8	6
	200	37	30	25
	300	75	60	50

Table 5 Comparison of properties and performance of ordinary and improved hot repair mixes

Service conditions	Temperature	1000~1200°C	
	Amount in each repair	500~800kg	
	Thickness (estimation)	100~150mm	
Characteristic		Improved resin bonded mix	Ordinary pitch bonded mix
Chemical composition (%)			
MgO		76.8	73.2
C		2.3	7.3
Cast body at 600°C			
Apparent porosity (%)		24.1	28.8
Bulk density (g/cm³)		2.51	2.32
Modulus of rupture (MPa)		12.0	12.2
1500°C×3 hours			
Apparent porosity (%)		26.6	32.7
Bulk density (g/cm³)		2.49	2.29
Modulus of rupture (MPa)		13.3	6.1
Hot modulus of rupture at 1400°C (MPa)		7.3	5.9
Hardening time (min)		15	45
Hot flowability		○	○
Degree of smoking		Little	Much
Durability		Approx. 10ch	Approx. 10ch

tion in a repair mass after 10, 20, and 30 minutes, calculated for the same conditions, such as a residual temperature of 1200°C, and a 200 mm thickness of the repaired mass. Results indicated that 25 minutes was required for the center of the repair mass to reach 250°C. So if the BOF was tilted within 10 minutes after placement of the repair mix, the interior of the repair mass would flow out.

Table 4 shows the calculation results. There was good correlation between the calculated results and results in the field. By estimation of the conditions required for the repair mixes, stable and improved durability can be achieved.

Based on the examination of the hardening mechanism for resin-bonded mixes, the hardening time required for repair mixes can be predetermined on the basis of the temperature of the brick surface and the thickness of the repair mass. By maintaining the required curing time, the repair work will be more effective and the lining life will be prolonged.

Table 5 shows a comparison of the properties for one of the improved repair mixes and an ordinary repair mix.

6. Conclusions

An experimental study of resin-bonded hot repair casting mixes has been conducted. The following results were obtained:

1. To shorten the hardening time, choose solvents with lower boiling point and resin with higher molecular weight.
2. To have excellent hot flowability, choose solvents with higher boiling point and resin with lower molecular weight.
3. The required hardening time for repair mixes can be predetermined in service on the basis of the temperature of the brick surface and the thickness of the repaired mass. Maintaining the required curing time contributes to effective repair work and prolongs the lining life.

References:

- 1) Akira Watanabe, Takeo Okamura, Fukuji Ohta: Taikabutsu 35 (10) 560-566 (1983)
- 2) Nobuyoshi Hiroki, Gensuke Muta, Takashi Miki, Akira Watanabe, Hirokuni Takahashi, Takanori Shimizu: Taikabutsu 42 (5) 266-267 (1990)

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